British Journal of
Sports Medicine

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Journal:	*British Journal of Sports Medicine*
Manuscript ID	bjsports-2017-098742.R3
Article Type:	Review
Date Submitted by the Author:	25-Apr-2018
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Keywords:	Exercise, Exercise rehabilitation

Defining adherence to therapeutic exercise for musculoskeletal pain: A systematic review.

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Funding:

D. Bailey is supported for this work through a Keele University, Research Institute for Primary Care and Health Sciences, ACORN PhD Studentship.

N.E Foster and A. Bishop were supported through a National Institute for Health Research (NIHR) Research Professorship awarded to N.E. Foster (NIHR-RP-011-015). Professor N.E. Foster is a NIHR Senior Investigator.

J.G. Quicke is supported by a NIHR Academic Clinical Lectureship in Physiotherapy, awarded as part of Professor C. Mallen's NIHR Research Professorship (NIHR-RP-2014-026).

K.L. Haywood is supported by Warwick Research in Nursing, Warwick Medical School, Warwick University.

The views expressed in this publication are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.

Disclosures or conflicts of interest: None

Word count: 4305 including headings

Keywords: Exercise, adherence, compliance, musculoskeletal pain, definition.

Author contributions - DB, NF, MH & AB contributed to the design of the review. DB executed the search strategy with input from NF, MH & AB. DB, NF, AB & JQ assessed studies for inclusion and extracted data from each of the included studies. DB analysed the data and developed the first draft. All authors interpreted the data, contributed to the critical revision of the manuscript and approved the final version.

Acknowledgements: None

ABSTRACT (248 words)

Objective: To establish the meaning of the term 'adherence' (including conceptual and measurement definitions) in the context of therapeutic exercise (TE) for musculoskeletal (MSK) pain.

Design: Systematic review using a search strategy including terms for: adherence, TE and MSK pain. Identified studies were independently screened for inclusion by two researchers. Two independent researchers extracted data on: study type; MSK pain population; type of TE used; definitions, parameters, measurement methods, and values of adherence.

Data sources: Seven electronic databases were searched from inception to December 2016.

Eligibility Criteria: Any study type featuring TE for adults with MSK pain and containing a definition of adherence, or a description of how adherence was measured.

Results: 459 studies were identified and 86 were included in the review. Most were prospective cohort studies and featured back and/or neck pain. Strengthening and stretching were the most common types of TE. A clearly identifiable definition of adherence was provided in 40% of the studies, with 12% using the same definition. Exercise frequency was the most commonly measured parameter of adherence, with self-report logs the most common measurement method. The most common value range used to determine satisfactory adherence was 80-99% of the recommended exercise dose.

Conclusion: No single definition of adherence to TE was apparent. We found no definition of adherence that specifically related to TE for MSK pain or described the dimensions of TE that should be measured. We recommend conceptualising adherence to TE for MSK pain from the perspective of all relevant stakeholders.

INTRODUCTION

There is strong evidence for exercise therapy as a treatment option for musculoskeletal (MSK) pain in primary care, with medium or large effect sizes for pain, function and quality of life outcomes[1]. The effects of exercise compare favourably with other treatments including self-management, manual therapy, oral and topical pharmacological treatments, and surgery[1]. Therapeutic exercise (TE) is an effective and safe treatment for MSK pain[2,3,4] and is recommended in many clinical guidelines[5,6,7,8]. However, the effectiveness of exercise is dependent upon the level of adherence to the recommended exercise protocol. A systematic review of 72 exercise treatments for low back pain (LBP) found that when adherence was encouraged to achieve a high dose of exercise, pain scores improved favourably compared to lower doses of exercise[9]. Higher exercise adherence can improve pain and physical function outcomes in patients with MSK pain and osteoarthritis (OA)[10,11]. Adherence was identified by an expert consensus group as an important factor for determining outcomes from exercise in patients with knee or hip OA[12]. To improve the effectiveness of exercise for MSK pain, various strategies to enhance adherence have been investigated, such as goal setting and automated reminders but with inconsistent results[13].

Three recent systematic reviews of measures of exercise and self-management methods for MSK pain[14,15,16], found that measures of exercise adherence currently used within randomised controlled trials are highly variable (including questionnaires, diaries and class registers), lack evidence of a robust or considered development process, and demonstrate inadequate psychometric properties for reliability and validity. There is no existing measure of adherence that is fit for purpose[14,15,16]. A valid and reliable measurement tool for adherence to TE for MSK pain is therefore required to enable interpretation of results from exercise trials and to robustly test the effectiveness of interventions intended to improve exercise adherence[13-16].

To develop a measurement tool, the concept of interest must first be understood[17] as the adequacy of an instrument will depend upon the conceptual framework from which it is developed[18]. However, exercise adherence is a multi-dimensional construct[19], which is poorly defined[16], with multiple synonyms used in the published literature to describe its meaning, such as: compliance, concordance, agreement, cooperation, partnership and therapeutic alliance[20]. These terms are regularly used interchangeably, although arguably were originally intended to convey different meanings. Compliance and adherence both refer to the patent-healthcare practitioner (HCP) interaction, but adherence is viewed as reflecting a less paternalistic relationship, with the patient as an active decision maker rather than passive recipient. Similarly, concordance is seen to better reflect the creation of a therapeutic alliance between the patient and HCP[21]. A common definition of

adherence used in the healthcare literature is that created by Sackett and Haynes in 1976[20,22], with the following modified iteration published in the World Health Organisation's (WHO) Adherence Project (2003)[23]: "the extent to which a person's behaviour – taking medication, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a healthcare provider". This definition was not specifically developed for MSK pain or TE, nor does it provide any guidance for operationalising the measurement of adherence in this context.

Therefore, to inform the development of a new measurement tool, this review aims to establish the dimensions of adherence to TE for MSK pain in adults reported in the published literature. The dimensions of adherence to TE among adolescents and children may be different to adults and warrants separate investigation. In this review, we use the term 'dimension' to refer to any single element that contributes towards the concept of adherence. In order to establish relevant dimensions of adherence, our objectives were: 1. Identify specific definitions of adherence used in the context of TE for MSK pain; 2. Identify the parameters used to assess TE adherence (where a parameter is a measurable aspect of adherence); 3. Identify the methods used to measure TE adherence; 4. Identify values used to classify satisfactory TE adherence.

METHODS

Search strategy

To maximise the sensitivity of the search, three separate search strings were combined, including terms for MSK pain, therapeutic exercise, and adherence. The search strategy was adapted from a Cochrane review of interventions to improve adherence to exercise for chronic MSK pain in adults[13]. The adherence terms were limited to the title only to restrict the search to studies in which adherence was the primary focus. A pilot search was conducted to refine the focus of the strategy while maintaining sufficient sensitivity to identify key studies already known to the authors. The review was not registered a priori.

Data sources

Seven databases were searched from inception to December 2016 using the OvidSP and EBSCO interfaces: MEDLINE, AMED, EMBASE, PsychINFO, HMIC, CINAHL and SPORTDiscus. The Cochrane Database of Systematic Reviews was also searched and free text searching using Google Scholar was carried out. The reference lists of included studies were checked, and Web of Science was searched for papers that had cited included studies to identify further titles that may have met the inclusion criteria. Identified titles and abstracts, then subsequent full texts were screened by pairs of

researchers (DB, AB, MH, JQ) independently, and any conflicts were arbitrated by an additional researcher (NF).

Studies were eligible if they featured all of the following:

1. A definition of exercise adherence - either an explicit definition such as a quote or citation, or a description of how exercise adherence was or should be measured.
2. Adults with MSK pain - including back, neck, hip, knee, ankle, foot, shoulder, elbow, wrist or hand pain, MSK conditions with wider systemic effects such as fibromyalgia and rheumatoid arthritis, post-surgical pain patients where the surgery was for a MSK condition, individuals with a non-specific diagnosis of MSK pain, and those with a specific diagnosis (e.g. OA or adhesive capsulitis) with or without supporting imaging or other diagnostic test results.
3. Therapeutic exercise - defined as any form of supervised or unsupervised exercise or physical activity specifically provided to patients to treat their MSK pain condition. Any type of exercise was included, such as strengthening, stretching, aerobic or mixed, and exercise delivered by an HCP, trained lay representative, fitness instructor, or delivered as part of a multi-disciplinary package of care. All study types were eligible, not just those where therapeutic exercise was being assessed as an intervention.

Studies were excluded if they:

1. Were not published in English.
2. Comprised conference proceedings where only the abstract has been published.
3. Involved exercise for a non-MSK pain condition, such as cancer, falls prevention, stroke or cardiac rehabilitation.
4. Included participants under 18 years.
5. Included participants with no MSK pain.

Data extraction

Data were extracted independently by two researchers using customised forms. Extracted data were compared for inconsistencies and any corrections made following discussion by the researchers. A third researcher was consulted if needed. We extracted: details of the study (design, country, setting), participant details (age, sample size, population, inclusion/exclusion criteria, MSK pain condition), the TE intervention (type, dosage, adherence measure time-point, exercise prescriber, supervised or unsupervised exercise), definitions of adherence (quotes or citations were extracted verbatim), the parameters of exercise adherence assessed (e.g. number of repetitions, attendances or intensity of exercise), methods used for measuring adherence (e.g. class register or self-report diary), and quantification or values assigned to adherence (e.g. number of exercises that

should be completed to be classed as adherent). Systematic reviews and protocols were included if they met the above criteria as it was possible they could include information about how adherence is defined. However, only data on the definition of adherence was extracted from systematic reviews to avoid the over-representation of studies that may have been included in a systematic review as primary research in this review.

Analysis

Data from included studies were summarised in tables. Terms used for describing parameters and measurement methods were standardised and frequency and percentage counts applied. Values for quantification of adherence were standardised by converting to percentages for ease of comparison and grouped according to commonly observed ranges. We did not formally assess the risk of bias since the methodological quality of included studies would not have influenced the utility or relevance of the data that were extracted for the purposes of this systematic review.

RESULTS

We identified 459 references, which reduced to 199 following screening of titles and abstracts. Finally, 86 studies met the inclusion criteria and were included in the review (Figure 1).

Characteristics of included studies

Included studies were published between 1976 and 2016 and originated from 20 different countries (Table 1). Sixteen different study types were included and hospital outpatients was the most common study setting (n=31). Seventeen different categories of MSK pain conditions featured, most commonly back and/or neck pain (n=30). The type of TE could be broadly grouped as: strengthening, stretching, aerobic, postural or mind-body exercise[24] (e.g. yoga), with strengthening (n=43) and stretching (n=35) being the most common. The time-point at which exercise adherence was measured in the studies varied from 1 week to 5 years.

Definitions of exercise adherence

Adherence data findings extracted from included studies are shown in appendix 2. Sixty per cent of studies (n=52) did not provide a clearly specified definition of adherence. Most studies defined adherence by describing the parameters by which it had been assessed (n=73, 85% of 86).

Thirty-four studies (40%) provided at least one clearly specified definition, the most common of which are shown in Table 2. Five studies provided definitions that were the authors' own or were uncited. Frost et al. (2016)[25] provided their own definition in addition to that of the WHO. Their

definition, "the extent to which individuals undertake prescribed behaviour accurately and at the agreed frequency, intensity and duration" was based on the four parameters of adherence they believed characterised rehabilitation prescriptions, namely: frequency, duration, intensity and accuracy.

Table 2. Definitions of adherence used in studies

Definition and source	Studies citing definition
"The extent to which a person's behaviour – taking medications, following a diet, and/or executing lifestyle changes, corresponds with agreed recommendations from a healthcare provider". (WHO 2003)	Beinart et al. (2013) Ezzar et al. (2014) Hall et al. (2014) Holden et al. (2014) Frost et al. (2016) Jack et al. (2010) Jordan et al. (2010) Pisters et al. (2010) Thompson et al. (2016) Van Koppen et al. (2016)
"The extent to which the patient's behaviour (in terms or taking medications, following diets or executing other lifestyle changes) coincides with the clinical prescription". (Sacket and Haynes 1976)	Alexandre et al. (2002) Brus et al. (1997) Brus et al. (1998) Ferguson and Bole (1979) Hammer et al. (2007) Medina-Mirapeix et al. (2009) Robinson et al. (2004) Schneider et al. (1998) Wig et al. (2004)
"Adherence is defined by the active cooperation and the attitude of the patient during the therapy session and during home exercise execution". "The term adherence refers to the extent to which patients follow the instructions of their healthcare providers". "Adherence is defined as the extent to which the patient undertakes the clinic-based and home-based prescribed components of the physiotherapy programme". (all attributed to Meichenbaum and Turk 1987)	Hugli et al. (2014) Huyser et al. (1997) Mannion et al. (2009)
"Where adherence implies active voluntary involvement in the planning and implementation of the treatment and is defined as the extent to which the patient undertakes the clinic-based and home-based prescribed components of the physiotherapy programme." "Adherence, which denotes a more contemporary approach to decision making in which the client or patient is an active and equal partner with the health professional." (both attributed to Carr 2001)	Mannion et al. (2009) Marks and Allegrante (2005)

Parameters used to assess exercise adherence

Frequency of exercise completion was the most commonly used parameter to assess adherence (n=47, 55%) (Table 3). Frequency was measured in different ways, including: exercise repetitions,

sets, or blocks of exercise time, and over different time-frames (e.g. exercises per day, week or month).

Behavioural parameters were measured to assess adherence in 16 studies (19% of 86). These included HCP assessed elements such as 'following guidance' and 'receptivity to change', as featured in the Sports Injury Rehabilitation Scale (SIRAS)[19], and self-reported elements such as 'barriers to exercise'. Session attendance, which required the patient to be present at a supervised exercise session, was assessed in 22 (26%) studies. This was slightly different to 'session completion' assessed in 11 (13%) studies, which was a self-reported or HCP observed completion of recommended exercises during an exercise session.

Exercise exertion or intensity was assessed in 13 studies (15%), subjectively in eight (9%) and objectively in five (6%). Seven studies (8%) assessed a parameter reflecting the quality of the patients' replication of the recommended exercises, which was determined via HCP observation.

Table 3. Number of studies describing parameters used to assess TE adherence

Parameter of TE adherence measured	Number of studies using parameter (%)
Exercise frequency	47 (55%)
Session attendance	22 (26%)
Behavioural component	16 (19%)
Exercise time	15 (17%)
Sessions completed	11 (13%)
Exercise exertion (subjective measure)	8 (9%)
Exercise replication	7 (8%)
Exercise intensity (objective measure)	5 (6%)

(NB. Some studies described more than one parameter, hence totals do not sum to 100%)

Methods used to measure adherence

Of the 86 included studies, 74 (86%) described at least one method of measuring adherence. The most common measurement methods were self-report exercise logs (n=44, 51%), registers of attendance (n=18, 21%) and an existing measurement scale (n=15, 17%). Thirty-three studies (38%) used more than one type of measurement method. Six studies used an objective measure of exercise adherence (e.g. pedometer) (Table 4). Within the category of 'existing measurement scales', 12 different measures of exercise adherence were identified. These included the SIRAS[19], General Adherence Scale (GAS)[26] and Adherence to Physiotherapists Recommendation Scale (APRS)[27].

Table 4. Number of studies describing a method of measuring TE adherence

Measurement method	Number of studies using method (%)
Self-report exercise log	44 (51%)
Class register	18 (21%)
Existing measurement scale	15 (17%)
Healthcare practitioner observation	11 (13%)
Self-developed questions	12 (14%)
Objective measure	6 (7%)
Interview	6 (7%)

(NB. Some studies described more than one method, hence totals do not sum to 100%).

Values for adherence

Half of the studies (n=44, 51%) did not provide information about what they considered to be a satisfactory value for TE adherence. Forty-two of the studies (49%) described values indicating 'satisfactory' TE adherence (Table 4). These were grouped into four ranges as shown in Table 5 . The most common range of values for satisfactory adherence was between 80-99% completion of the prescribed exercise/s. Six studies (7%) provided values specifically describing 'low adherence'. These varied between 0-79% completion of the recommended exercises. It was unclear in many of the studies whether cut-off points for satisfactory adherence were determined *a priori* or *post hoc*, as they were not described in the methods. Where cut-off points were stated, no references to required therapeutic dosages or other guidelines were mentioned. Some studies used the

distribution of participants' adherence data to assign a value of satisfactory adherence. For example, Granlund et al. (1998)[28] used the median value of participants' adherence results to dichotomise them into adherent or non-adherent groups, whereas Van Gool et al. (2005)[29] ordered the participants according to their adherence results, then divided them into three equally sized groups described as 'low', 'intermediate' or 'high' adherence.

Table 5. Number of studies stating values for satisfactory TE adherence

Value for satisfactory adherence	Number of studies using this level
100% of recommended dose	8 (9%)
80-99% of recommended dose	15 (17%)
60-79% of recommended dose	9 (10%)
14-59% of recommended dose	10 (12%)
No value given	44 (51%)

DISCUSSION

We aimed to establish the dimensions of adherence to TE for MSK pain, in other words, all information reported in relevant published literature that contributes towards the concept or meaning of adherence. This was achieved by identifying: specific definitions of TE adherence; the parameters used to assess TE adherence; the methods used to measure TE adherence and values for satisfactory adherence. We included studies from a wide range of countries featuring various methodologies, settings, MSK pain conditions, and TE interventions. Most commonly, study authors did not state a definition of TE adherence, even when this was a focus of their study. Where a definition was stated, most originated from the work of Sackett and Haynes (1976)[22].

Exercise frequency was the most common parameter by which TE adherence was assessed, although it was commonly combined with other parameters. A variety of methods of TE adherence measurement were reported. A self-report exercise log was the most frequently used method, although the structure and implementation of these methods varied between studies. Most studies

did not define what was considered a satisfactory level of adherence, however 80-99% completion of the recommended exercises was most frequently used as a surrogate of satisfactory adherence.

Definitions of adherence

Most studies did not state a definition of adherence. This may be because a definition of adherence that is explicitly related to adherence to TE does not exist. Alternatively, it might be that the meaning of adherence is so clear, having undergone so little development between the 1976 version by Sackett and Haynes to the 2003 version from the WHO, that there is an assumption that the term is tacitly understood among research and clinical communities. However, the lack of an agreed communicable definition of adherence is a problem, because without a clear picture of what adherence is, HCPs and patients cannot work together to achieve adherence as a shared goal, nor measure or monitor its variability.

The original definition by Sackett and Haynes (1976)[22] used the term 'compliance' not 'adherence', and concerns therapeutic regimens generally, not specifically MSK pain or TE. While the more recent WHO iteration of this definition (2003)[23] uses the term 'adherence', to better reflect the autonomy of the patient and his/her role as an 'active partner' in the treatment process, it was developed by groups of experts focussing on adherence issues relating to chronic health conditions other than MSK pain (including hypertension, epilepsy, HIV and tuberculosis). Consequently, pharmacological intervention was the main treatment of concern for both these definitions, but it is not clear whether adherence to TE can be defined in the same way. These possible differences may explain why the WHO definition (2003)[23] has not been universally applied to TE for MSK pain. The WHO definition lacks specificity, providing no indication of the parameters of treatment adherence that should be assessed, how they should be measured, or what levels of adherence should be expected. This ambiguity means definitions can be interpreted differently, as shown by this review, where several interpretations of a single definition were associated with authors using different parameters, measurement methods and cut-offs.

It has been proposed that the term compliance should be used in efficacy trials where the intervention has been determined according to the desired outcome and target population, but not necessarily the individual patient or recipient[30]. Adherence on the other hand, is proposed to reflect the effectiveness of TE in trials or real-life contexts[30]. Adherence considers the individual's role in interpreting the appropriateness of the advised intervention and the influences upon their behaviour and motivation, such as the environment, society, previous experience, knowledge, symptoms, and resources. Adherence is a more complex measurement than simply comparing to a reference standard intervention dose[30]. Until the message we are trying to convey with these terms

is clarified by all those to whom it pertains, including patients, the uptake of existing definitions may remain inconsistent in MSK pain and TE literature.

The definition of adherence provided by Frost et al. (2016)[25] is specific to TE for MSK pain and identified the parameters of TE adherence that should be measured: frequency, duration, intensity, and accuracy. However, its development was based on stroke rehabilitation[31], public health[32], falls prevention[33] and the use of exercise sheets in physiotherapy,[34] not literature focussing specifically on TE prescription for MSK pain. Therefore, it is possible that the definition does not reflect the perceptions of patients with MSK pain or HCPs responsible for prescribing TE. While Frost et al. (2016)[25] offer the first operational definition of TE adherence, its four parameters are different to those identified as most commonly used in this review. Therefore, the concept of adherence to TE for MSK pain may require further refinement before the development of a new measure of adherence.

Parameters of adherence

We identified 8 categories of TE adherence parameters (measurable aspects of adherence). The most common was exercise frequency, a finding consistent with other reviews, suggesting it is a relevant dimension of TE adherence, or simply an easy parameter to measure. However, even exercise frequency was assessed in various ways (e.g. repetitions or blocks of time, per day or week), suggesting it is more complex than a simple representation of the total TE undertaken.

The accuracy with which patients replicated their exercises, or the quality of their exercise performance was included as a parameter in 7 studies. The scant attention paid to accuracy or quality of performance may be because it is not an important dimension of TE adherence, or that it is too challenging to incorporate into research, despite being a common parameter of adherence to assess in clinical practice[15]. HCP observation has been recommended in the assessment of TE adherence[35] and is a feature of one of the more commonly used measures: the SIRAS[36]. For research purposes, the constraint of requiring an observer and its associated cost implications may be why these parameters have not been regularly assessed. While technology may be able to objectively measure certain parameters of TE[37], the expense of such equipment, the expertise required to operate it and the number of sensors required to measure more complex TE interventions, may limit its implementation[38]. The acceptability of the equipment by patients may also limit its effectiveness as a measurement tool, as patients may not adhere to using the measurement device, despite adhering to the TE intervention. Natural adherence behaviour may also be affected by overt monitoring, such as wearing a measurement device, although similar changes may also be associated with subjective measurement methods.

Behavioural components featured in 16 studies, two of which, used self-reported barriers to exercise completion as a parameter of adherence[39, 40]. This is an uncommon approach, as barriers are normally seen as modifiers of adherence levels. However, poor treatment adherence has been associated with a greater perceived number of barriers[41] indicating a potential role for barriers in the assessment of adherence. Some studies identified single parameters of TE adherence, whereas other studies identified combinations of parameters (e.g. exercise frequency and session attendance), without justification. These findings suggest there are multiple relevant parameters of adherence to TE, but no consensus as to their importance or relevance to a specific context. This may relate to non-specific definitions such as the WHO's focus on pharmacological interventions, whereas TE prescription may potentially have more parameters contributing to adherence, such as: frequency, intensity, time, accuracy or a behavioural component, which require different methods for their measurement.

Methods of measuring adherence

Multiple methods of measuring exercise adherence were identified, including self-report exercise logs, class registers and existing measurement scales, mirroring the findings from recent systematic reviews[14,15,16]. However, different measurement methods were used across studies for the same adherence parameter. For example, the parameter of session attendance was measured using a class register, interview and self-report log. Such variation is understandable given the multiple parameters of adherence and the non-specific guidance provided by the WHO's adherence report[23], which suggests, "a multi-method approach combining self-reporting and objective measures". However, the lack of a single valid and reliable measurement tool of TE adherence means that the relative effectiveness of interventions is difficult to compare across studies[13,14,15,16].

There was large variability in time points at which adherence was measured, varying from 1 week to 5 years. As adherence is likely to change over time[13], the point at which adherence is measured could substantially influence the rates of adherence observed. To improve the comparability of data, it may be useful to establish adherence measurement timescales (e.g. short, medium and long-term). There should also be improved clarity in the reporting of adherence measurement timing (e.g. whether measurements took place daily, weekly or monthly), and for studies where there are multiple deliveries of the TE intervention (e.g. weekly exercise classes), the time interval between the TE delivery and the adherence measurement.

Values of adherence

Fewer than half of included studies (49%) defined satisfactory adherence. Two approaches were used, either a pre-determined cut-off or a distribution method. Distribution-based methods result in

the adherence of an individual being judged relative to the performance of other study participants, rather than any pre-determined target level of adherence. This explains why satisfactory adherence levels ranged from 14-100% completion of prescribed exercises in this review. Only one study, Hammer et al. (2007)[42] used pre-determined adherence categories justified from the literature.[43] However, the original source provides no explanation of how these categories were derived. In our review, satisfactory adherence was most commonly valued between 80-99% completion of the prescribed exercises (n=15, 17%). Furthermore, several studies described low adherence, providing ranges of prescribed exercise completion between 0 and 79%. This may suggest that 80% could be a reasonable threshold for satisfactory adherence.

If specific TE doses are unknown, it may be inappropriate and unhelpful to set arbitrary adherence cut-off points for TE interventions for MSK pain. A systematic review and meta-analysis of medication adherence showed that good adherence to placebo medication was associated with lower mortality, a so called 'healthy adherer' effect[44]. Therefore, it may be beneficial for a patient to identify as adherent, even in the absence of a known therapeutic dosage. Identifying an MSK patient as non-adherent when the therapeutic dosage of TE is unknown, may deny the patient the benefits of the healthy adherer effect.

Research and clinical Implications

There is a need to focus on establishing a clear definition of adherence specifically relating to TE for MSK pain, and the best way to measure adherence. Patients must be involved as active, collaborative partners in future research so that the resulting construct of exercise adherence incorporates their views[45]. In the absence of a valid, reliable and acceptable measure of TE adherence for MSK pain, the interpretation of results from trials investigating TE interventions or methods for improving TE adherence may be questioned. This underscores the importance of agreeing upon a satisfactory measure/s. From the clinician's perspective, if he or she cannot be sure of how to accurately define and measure adherence, it may be difficult to determine whether a patient's lack of progress despite treatment is due to inadequate engagement or ineffective treatment.

Limitations

We adopted an inclusive approach using a modified versions of an established Cochrane search strategy to include all study types and MSK pain conditions, however, it is possible that some studies relating to adherence to TE for MSK conditions may have been missed. To minimise error and bias, two independent reviewers assessed both title and abstract and full text papers for inclusion and data extraction. The search terms were limited to title, or title and abstract. Restricting the search in

this way, ensured that the included studies were specifically focused on adherence in the context of TE for MSK pain and therefore more likely to be appropriate to this review. It is possible that some relevant studies may have been missed that did not feature adherence in their title. However, different search strategies were piloted to achieve results with a focus on adherence while maintaining acceptable sensitivity.

Since a definition of adherence was not provided in the majority of included studies despite their title featuring a term for adherence, it is unlikely that articles not featuring an adherence term in their title would discuss the concept in any detail. Equally, the majority of definitions used were from the same source, and it is unlikely that this would change if more articles were reviewed. Six studies were excluded as they were not published in English. Consequently, our review is at risk of language bias, and the results may under-represent studies that are not published in English. The countries of origin of the excluded studies were still represented in the final 86 included studies. No low-income countries were studied. Therefore, our findings may only be generalisable to high income countries and their cultures.

CONCLUSION

Most studies did not state a definition of adherence. Definitions most commonly used in the context of TE for MSK pain were not developed specifically for TE or MSK pain, and did not describe the context specific dimensions of this concept. The variability of the parameters of adherence assessed, the wide variety of measurement methods used, and the seemingly arbitrary nature of determining values for satisfactory adherence, lack sufficient consistency and detail as to inform a definition of adherence or the required content of a suitable measure.

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SUMMARY

- Patients' adherence to therapeutic exercise prescribed for MSK pain is important for outcomes.
- The most commonly used definition of adherence was not developed specifically for MSK pain and lacks detail on the important dimensions or cut-point from which to determine satisfactory adherence.
- The meaning of adherence in the context of therapeutic exercise for MSK pain is unclear and should be conceptualised by relevant stakeholders.

APPENDIX

1. Search strategy

1. exp pain/
2. pain.ti,ab.
3. 1 or 2
4. joint/ or joint$.ti,ab.
5. back.ti,ab.
6. knee.ti,ab.
7. shoulder.ti,ab.
8. neck.ti,ab.
9. elbow.ti,ab.
10. hand.ti,ab.
11. hip.ti,ab.
12. foot.ti,ab.
13. feet.ti,ab.
14. 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13
15. 3 and 14
16. exp back pain/
17. neck pain.ti,ab.
18. sciatica.ti,ab.
19. referred pain.ti,ab.
20. (musculoskeletal adj2 (disease$ or disorder$ or pain)).ti,ab.
21. (chronic adj2 pain).ti,ab.
22. (radiculopathy or radicular).ti,ab.
23. (osteoarthr$ or arthriti$ or arthros?s).ti,ab.
24. (referred adj2 pain).ti,ab.
25. fibromyalgia.ti,ab.
26. 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25
27. exp exercise/
28. exercis$.ti,ab.
29. exp exercise therapy/
30. (physical adj1 (active or activities or activity)).ti,ab.
31. exp rehabilitation/
32. (rehab or rehabilitation).ti,ab.
33. 27 or 28 or 29 or 30 or 31 or 32
34. concordance.ti.
35. (adhere$ or adhering).ti.
36. (complian$ or complying).ti.
37. nonadher$.ti.
38. noncomplian$.ti.
39. "therapeutic alliance".ti.
40. conformity.ti.
41. cooperation.ti.
42. 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41
43. 26 and 33 and 42

2. Table of adherence data extracted from included studies

Study ID	Study overview	Explicitly stated definitions of adherence.	Parameters used which define adherence.	Measures of adherence used.	Quantification of adherence.
Alexandre et al. 2002	**Design:** Prospective cohort study **Condition**: LBP **Setting:** Hospital outpatient **Exercise intervention**: Aerobic, strengthening, stretching and postural **Adherence:** between 2 to 6 weeks	"The extent to which a person's behaviour (in terms of taking medications, following diets, or achieving lifestyle changes) coincides with advice from physicians or other healthcare providers." [1] "We defined compliance as the extent to which a patient's behaviour coincided with a clinical prescription. We defined noncompliance as not adhering to prescribed physical therapy appointments, educational activities, and/or a	Exercise session attendance Reported exercise frequency	Class register Self-report exercise log	High compliance = 80% or more attendance. Low compliance = less than 80% attendance. No compliance = attending no sessions.

		home exercise regimen." [2]			
Almekinders & Almekinders 1994	**Design:** Retrospective study **Condition:** Chronic overuse sports injury **Setting:** Private physiotherapy **Exercise intervention**: Strengthening and stretching **Adherence:** 27 months on average	None provided	Whether the participants followed the physical therapy programme as prescribed	Telephone questionnaire	None provided
Anderson 2011	**Design:** Prospective study nested within an RCT **Condition:** Neck and shoulder pain **Setting:** Community **Exercise intervention**: Strengthening **Adherence:** 10 weeks	None provided	Reported exercise sessions completed	Self-report exercise log	High adherence = 60% of recommended exercises completed. Medium adherence = 20-60% of recommended exercises completed. Low adherence = less than 20% of recommended exercises completed
Basler et al. 2007	**Design:** Prospective randomised trial **Condition:** Chronic LBP **Setting:** Hospital inpatient **Exercise intervention:** Aerobic, strengthening, stretching **Adherence:** 6 or 7 weeks and 6 months	None provided	Whether 30 minutes of recommended daily physical activity was achieved	Self-report exercise log	None provided
Beinart et al. 2013	**Design:** Systematic Review **Condition:** Chronic LBP **Setting:** Community **Exercise intervention:** Various	"The extent to which a person's behaviour corresponds with	None provided in addition to those in included articles	None provided in addition to those in included articles	None provided in addition to those in included articles

	Adherence: Various	agreed recommendations from a healthcare provider"[3]			
Belza et al. 2002	**Design:** RCT **Condition:** OA **Setting:** Community **Exercise intervention:** Aquatic **Adherence:** 20 weeks	None provided	Session attendance	Self-report exercise log	Adherence = attending at least 2 classes per week for 16 of 20 weeks (i.e. >80%).
Bossen et al. 2013	**Design:** Mixed methods study of one treatment arm of a previous RCT **Condition:** Knee or hip OA **Setting:** Community **Exercise intervention:** Aerobic **Adherence:** 9 weeks	None provided	The number of modules completed	Self-report exercise log (via computer based software which also monitored engagement)	Adherence = completion of at least 6 out of 9 modules (i.e. >66%).
Bruno 1995	**Design:** Prospective cohort study **Condition:** Back or neck pain resulting from motor vehicle or work-related accidents **Setting:** Hospital inpatient and outpatient **Exercise intervention:** Aerobic, stretching, posture and self-care activities. **Adherence:** 12 weeks	None provided	Failure to increase or decrease activity levels as recommended by HCPs	Session attendance Self-report exercise log HCP observation	Non-adherence = failure to comply with the rehabilitation programme on more than one occasion.
Brus et al. 1997	**Design:** Literature review **Condition:** RA **Setting:** Various **Exercise intervention**: Various **Adherence:** Various	"The extent to which a person's behaviour coincides with the medical or health advice."[1]	None provided in addition to those in included articles	None provided in addition to those in included articles	None provided in addition to those in included articles
Brus et al. 1998	**Design:** RCT **Condition:** RA **Setting:** Hospital outpatient **Exercise intervention:** Aerobic	"The extent to which a person's behaviour coincides with the medical or	Exercise frequency Exercise time (minutes)	Questionnaire	None provided

	Adherence: 1 year	health advice"[1]			
Byerly et al. 1994	**Design:** Cohort study **Condition:** Musculoskeletal injury **Setting:** Private physiotherapy **Exercise intervention:** Not stated **Adherence:** Until discharged	None provided	Session attendance (0 or 1 point) Session % completion (0, 0.25, 0.5, 0.75 or 1 point)	Class register HCP observation	Adherence = average daily score of 1.75 - 2.0 (i.e. >88%).
Campbell et al. 2001	**Design:** Qualitative study nested in RCT **Condition:** Patellofemoral OA **Setting:** Outpatient physiotherapy **Exercise intervention:** Strengthening **Adherence:** 3 and 12 months	"Non-compliance is traditionally defined as a failure by patients to follow advice."[4,5]	None provided	HCP observation	None provided
Carpenter & Davis 1976	**Design:** Cohort study **Condition:** RA **Setting:** Hospital inpatient **Exercise intervention:** Not stated **Adherence:** 4 months	"Compliance may for example be operationally defined in both quantitative and qualitative terms; in terms of how much the patient complies and how well he complies. Does the patient perform and exercise as often as prescribed and exactly as directed?" No citation	Sessions completed	Questionnaire Self-report exercise log HCP observation	Adherence = completion of the exercise regimen as described (i.e. 100%).
Cheung et al. 2015	**Design:** Cross sectional survey **Condition**: Knee OA	None provided	Time Frequency	Self-report exercise log	No

	Setting: Community **Exercise intervention:** Other: yoga **Adherence:** 6 months		Accuracy	Interview Video tape	
Coppack et al. 2012	**Design:** RCT **Condition:** LBP **Setting:** Private physiotherapy **Exercise intervention:** Aerobic, strengthening, stretching, movement coordination **Adherence:** 3 weeks	None provided	Participant's exertion Participant's compliance with HCP instructions Participant's receptivity to programme change	Sport Injury Rehabilitation Adherence Scale (SIRAS)	None provided
Dalager et al. 2015	**Design:** RCT **Condition:** Neck and shoulder pain **Setting:** Community **Exercise intervention:** Strengthening **Adherence:** 20 weeks	None provided	Exercise repetitions Exercise time	Self-report exercise log Self-reported compliance 1-6 scale	At least 40 minutes of 60-minute recommendation (i.e. 66%)
Dobkin et al. 2006	**Design:** Prospective study nested in RCT **Condition:** Fibromyalgia **Setting:** Community **Exercise intervention:** Aerobic, strengthening, stretching **Adherence:** 12 weeks	"Attrition from treatment is the variable used most often to approximate adherence"[6,7,8] "Almost all the exercise studies reviewed defined adherence as the number of sessions attended"[9-12]	Exercise frequency Exercise time (minutes)	Self-report exercise log	Adherence = 100% completion of prescribed exercises.
Dobkin et al. 2008	**Design:** Prospective study **Condition:** Fibromyalgia **Setting:** Hospital outpatient **Exercise intervention:** Aerobic, strengthening, stretching	"Attendance at treatment sessions"[13-16]	Session attendance Exercise frequency Reported difficulty in following recommendations	Class register General Adherence Scale (GAS) Specific Adherence Scale (SAS)	87% observed median session attendance was described as "very good".

	Adherence: 3 months				
Dobkin et al. 2009	**Design:** Prospective study **Condition:** Fibromyalgia **Setting:** Hospital outpatient **Exercise intervention:** Aerobic, strengthening, stretching **Adherence:** 3 months	None provided	Reported difficulty in following recommendations Exercise frequency	General Adherence Scale (GAS)	None provided
Ezzat et al. 2014	**Design:** Systematic review **Condition:** RA or OA **Setting:** Various **Exercise intervention:** Various **Adherence:** Various	"Adherence can be defined as the extent to which a person's behaviour corresponds with the agreed recommendations from healthcare providers"[3]	None provided in addition to those in included articles	None provided in addition to those in included articles	None provided in addition to those in included articles
Ferguson & Bole 1979	**Design:** Cohort study **Condition:** RA **Setting:** Hospital outpatient **Exercise intervention:** Not stated **Adherence:** Not stated	"The extent to which a person's behaviour coincides with the medical or health advice"[1]	Exercise frequency	Self-report exercise log	None provided
Friedrich et al. 1998	**Design:** Double blinded prospective RCT **Condition:** LBP **Setting:** Hospital outpatient **Exercise intervention:** Aerobic, strengthening, stretching **Adherence:** 4 and 12 months	None provided	Session attendance Exercise time (minutes)	Class register Self-report exercise log	None provided
Frih et al. 2009	**Design:** Prospective RCT **Condition:** LBP **Setting:** Hospital outpatient **Exercise intervention:** Strengthening, stretching and self-positioning **Adherence:** 4 weeks and 3 months	None provided	Exercise frequency	HCP observation	None provided

Frost et al. 2016	**Design:** Systematic review **Condition**: Any **Setting:** Community **Exercise intervention**: n/a **Adherence:** n/a	"Adherence is the extent to which a person's behaviour coincides with agreed clinical recommendations"[3] "The extent to which individuals undertake a prescribed behaviour accurately and at the agreed frequency, intensity and duration" No citation	None provided in addition to those in included articles	None provided in addition to those in included articles	None provided in addition to those in included articles
Granlund et al. 1994	**Design:** Cohort study **Condition:** LBP **Setting:** Community **Exercise intervention:** Aerobic, strengthening, stretching, postural, relaxation **Adherence:** 5 and 10 months	None provided	Session attendance	Questionnaire	None provided
Granlund et al. 1998	**Design:** Cohort study **Condition:** LBP **Setting:** Community **Exercise intervention:** Strengthening, stretching **Adherence:** Weekly for 5 months	None provided	Session attendance	Class register	Observed median adherence = 16.1% higher adheres = >16.1% Lower adherers = <16.1% Mean adherence rate of 35.7% was described as quite low.

Gisla et al. 2015	**Design:** Evidence based practice project **Condition**: CLBP **Setting:** Hospital outpatient **Exercise intervention**: Stretching **Adherence:** 3, 6 and 12 months	No	Exercise frequency	Self-developed questions in questionnaire	Compliance defined as completing the exercises 50% of the time or more
Hakkinen et al. 2004	**Design:** RCT **Condition:** RA **Setting:** Hospital outpatient **Exercise intervention:** Strengthening, stretching **Adherence:** 2 and 5 years	None provided	Exercise frequency Exercise time (minutes)	Questionnaire Self-report exercise log	None provided
Hall et al. 2015	**Design:** Systematic review **Condition:** Chronic musculoskeletal conditions **Setting:** Various **Exercise intervention:** Various **Adherence:** Various	"The extent to which a person's behaviour (taking medication, following a diet or exercise plan, and/or executing lifestyle change), corresponds with recommendations from a healthcare professional."[3]	None provided in addition to those in included articles	None provided in addition to those in included articles	None provided in addition to those in included articles
Han et al. 2015	**Design:** Retrospective database study **Condition**: ACL reconstruction **Setting:** Hospital outpatient **Exercise intervention**: Strengthening/Aerobic/Other: neuromuscular & sport specific training **Adherence:** 1 year	No	Session attendance	Register by HCP	Fully Compliant = attend 16 out of 20sessions (>80%), moderately compliant = 6-15 sessions (25%-75%), and noncompliant = less than 6 sessions

					(<25%).
Hammer et al. 2007	**Design:** Prospective study **Condition:** LBP **Setting:** Community **Exercise intervention:** Repeated movements according to directional preference **Adherence:** 2 months	"This phenomenon is usually referred to as compliance the reaching by patients of pre-established performance goals…"[17] "… or adherence the responsible co-operation in treatment by a patient."[18,19]	Exercise frequency	Self-report exercise log	Low compliance = 0-33% Moderate compliance = 34-66% High compliance = 67%[20]
Harkapaa et al. 1989	**Design:** Prospective RCT **Condition:** LBP **Setting:** Hospital inpatient and hospital outpatient **Exercise intervention:** Strengthening, stretching, postural **Adherence:** 3 months	None provided	Exercise replication Exercise frequency	HCP observation Interview	None provided
Harkapaa et al. 1990	**Design:** Prospective RCT **Condition:** LBP **Setting:** Hospital inpatient and hospital outpatient **Exercise intervention:** Strengthening, stretching, postural **Adherence:** 2.5 years	None provided	Exercise replication Exercise frequency	HCP observation Interview	None provided
Hartigan et al. 2000	**Design:** Prospective observational study **Condition:** LBP **Setting:** Hospital outpatient **Exercise intervention:** Aerobic, strengthening, stretching	None provided	Exercise frequency	Self-report exercise log Objective physical function measures	None provided

	Adherence: 3 and 12 months				
Hicks et al. 1985	**Design:** Review **Condition:** RA **Setting:** Various **Exercise intervention:** Various **Adherence:** N/A	"Compliance in reference to rheumatic disease is the extent to which a person's behaviour in terms of taking medication, following rehabilitation treatment plans, or executing lifestyle changes coincides with medical or health advice" No citation.	None provided in addition to those in included articles	None provided in addition to those in included articles	None provided in addition to those in included articles
Hicks et al. 2012	**Design:** Observational study **Condition:** Back pain **Setting:** Community **Exercise intervention:** Strengthening, postural, flexibility and aerobic **Adherence:** Continuously over 12 months	None provided	Session attendance	Class register	Adherence = participation in 75% of the exercise sessions over 12 months.
Holden et al. 2014	**Design:** Systematic review protocol **Condition:** Musculoskeletal disorders **Setting:** Primary care **Exercise intervention:** Various **Adherence:** N/A	"the extent to which a person's behaviour corresponds with agreed recommendations from a healthcare provider"[3]	None provided in addition to those in included articles	None provided in addition to those in included articles	None provided in addition to those in included articles
Hugli et al. 2014	**Design:** Randomised controlled pilot trial **Condition:** Non-specific low back pain	"Adherence is defined by the	Exercise time Participant's	Self-report exercise log	None provided

	Setting: Community **Exercise intervention:** Augmented feedback motor control exercise **Adherence:** on average at 49 days	active cooperation and the attitude of the patient during the therapy session and during HE execution"[20]	exertion Participant's compliance with HCP instructions Participant's receptivity to programme change	SIRAS	
Huyser et al. 1997	**Design:** RCT **Condition:** Fibromyalgia **Setting:** Hospital outpatient **Exercise intervention:** Aerobic, strengthening, stretching, postural **Adherence:** Weekly over 6 weeks	"The term adherence refers to the extent to which patients follow the instructions of their healthcare providers"[20]	Exercise frequency	Questionnaire	Adherence = 3 or more exercise sessions a week. Prescribed dosage not stated. Median adherence rate of 5 across the groups were described as high. This equated to participants completing their exercises 3 or more times per week in 5 out of the 6 weeks (i.e. 83%)
Jack et al. 2010	**Design:** Systematic review **Condition:** Musculoskeletal dysfunction **Setting:** Physiotherapy outpatient **Exercise intervention:** Various **Adherence:** N/A	"The extent to which a person's behaviour corresponds with agreed recommendations from a healthcare provider"[3]	None provided in addition to those in included articles	None provided in addition to those in included articles	None provided in addition to those in included articles
Jackson 1994	**Design:** RCT	"The extent to	Exercise frequency	Self-report exercise	None provided

	Condition: Back and/or neck pain **Setting:** Hospital in patient **Exercise intervention:** Not stated **Adherence:** 3 weeks	which patients decide to follow the recommendations of their physician or other health professional"[21]		log	
Jansons et al. 2016	**Design:** Systematic review **Condition**: OA **Setting:** Various **Exercise intervention**: n/a **Adherence:** n/a	No	Exercise frequency	None provided in addition to those in included articles	None provided in addition to those in included articles
Jordan et al. 2010	**Design:** Systematic review **Condition:** Persistent or episodic pain lasting more than three months in the axial skeleton (neck and low back) or large peripheral joints (hip, knee, shoulder). **Setting:** Primary Care **Exercise intervention:** Various **Adherence:** N/A	"the extent to which a person's behaviour corresponds with agreed recommendations from a healthcare provider"[3]	Summarised as: Exercise frequency Exercise time (minutes) Sessions completed Exercise replication	None provided in addition to those in included articles	None provided in addition to those in included articles
Kingston et al. 2014	**Design:** RCT **Condition:** Traumatic hand injury **Setting:** Hospital outpatient **Exercise intervention:** Not stated **Adherence:** 6 weeks	None provided	Exercise frequency Exercise time (minutes) Exercise replication Session attendance	Self-report exercise log Class register HCP observation	None provided
Kolt & McEvoy 2003	**Design:** Cohort study **Condition:** Lumbar pain **Setting**: Private Physiotherapy clinics **Exercise intervention**: Not stated **Adherence:** Weekly, up to the point of discharge (maximum 4 weeks)	None provided	Session attendance Exercise frequency Participant's exertion Participant's compliance with HCP instructions Participant's receptivity to	HECA SIRAS	Observed mean attendance of 87.7% described as high.

			programme change		
Lee et al. 2016	**Design:** Mixed methods pilot study (cohort study) **Condition**: Knee OA **Setting:** Community **Exercise intervention**: Strengthening/Stretching/Other: range of movement **Adherence:** 12 weeks	No	Exercise frequency Exercise accuracy	Self-report exercise log	Mean adherence of 91% described as high.
Linton & Jenson 1987	**Design:** Cohort study **Condition:** Neck and shoulder pain **Setting:** Community **Exercise intervention:** Relaxation gymnastics **Adherence:** 5 weeks	None provided	Exercise frequency	Self-report exercise log	Adherence = exact completion of prescription of 6 exercises per day (i.e. 100%).
Linton et al. 1996	**Design:** RCT **Condition:** Back pain **Setting:** Community **Exercise intervention:** None specifically recommended **Adherence:** 6 months	None provided	Exercise frequency	Self-report exercise log	Adherence = 100% completion of prescribed exercises.
Loew et al. 2016	**Design:** Survey **Condition**: Knee OA **Setting:** Community **Exercise intervention**: Aerobic (walking) **Adherence:** 3, 6 and 9 months	"The extent to which a person follows and accepts a treatment recommended by health professionals and is able to successfully reach the therapeutic goals"[22]	Session attendance Session completion	Self-report exercise log	Adherent if completing 2 of 3 prescribed sessions (66%)
Lonsdale et al.	**Design:** RCT outline	None provided	Session attendance	Short Form Physical	None provided

2012	**Condition:** Low back pain **Setting:** Outpatient physiotherapy **Exercise intervention:** Not specified **Adherence:** 4, 12 and 24 weeks		Exercise frequency Participant's exertion Participant's compliance with HCP instructions Participant's receptivity to programme change	Activity Questionnaire SIRAS (adapted) HECA (adapted) Adherence to Physiotherapists Recommendation Scale (APRS)	
Lyncoln et al. 2002	**Design:** Cohort study **Condition:** Distal fracture of radius **Setting:** Hospital-in patient **Exercise intervention:** Strengthening, stretching and functional **Adherence:** 6 weeks	"The term adherence can comprise a wide variety of behaviours, including performance of home exercises, attending therapy appointments and following health practitioner's advice during appointments."[23]	Sessions completed Exercise frequency Participant's exertion Participant's compliance with HCP instructions Participant's receptivity to programme change	Self-report exercise log SIRAS Class register	None provided
Mailloux et al. 2006	**Design:** Case series design with survey data collection **Condition:** Chronic back pain **Setting:** Hospital outpatient delivered by private physiotherapists **Exercise intervention:** Aerobics, strengthening and stretching **Adherence:** 2 years	None provided	Exercise frequency	Questionnaire	Adherence = exercising at least once a week (participants were advised to exercise on a daily basis) i.e. 14%.
Mannion et al. 2009	**Design:** Prospective study **Condition:** Low back pain	"Where adherence implies active	Session attendance Exercise frequency	Class register Self-report exercise	Observed median values of: MAI 89%:

	Setting: Primary care/hospital-out patient **Exercise intervention:** Spinal segmental stabilisation **Adherence:** 9 weeks	voluntary involvement in the planning and implementation of the treatment and is defined as the extent to which the patient undertakes the clinic-based and home-based prescribed components of the physiotherapy programme."[20, 24, 25]	Participant's exertion Participant's compliance with HCP instructions Participant's receptivity to programme change	log SIRAS Multi-dimensional Adherence Index (MAI combining % values of above measures)	attendance 100%: commitment (SIRAS) 96%: and home exercise completion 75% were described as 'very good'.
Marks & Allegrante 2005	**Design:** Literature review **Condition:** OA **Setting:** N/A **Exercise intervention:** Various **Adherence:** N/A	"Adherence, which denotes a more contemporary approach to decision making in which the client or patient is an active and equal partner with the health professional."[26]	None provided in addition to those in included articles	None provided in addition to those in included articles	None provided in addition to those in included articles
Mayoux-Benhamou et al. 2008	**Design:** Prospective RCT **Condition:** RA **Setting:** Hospital outpatient **Exercise intervention:** Strengthening and stretching **Adherence:** 6 and 12 months	None provided	Exercise frequency	Self-report exercise log Baecke questionnaire-recording habitual physical activity	Adherence = >30% completion of prescribed exercises.
Medina-Mirapeix et al. 2009	**Design:** Observational study **Condition:** Chronic non-specific neck or low back pain	"Adherence has been defined as the extent to which a	Exercise frequency Exercise time (minutes)	Questionnaire	Adherence = "always" or "almost always" complying

	Setting: Primary Care **Exercise intervention:** Strengthening and stretching **Adherence:** 1 month (after the 4 weeks of supervised exercises).	person's behaviour coincides with professional advice."[27]			to exercise recommendation as reported on the questionnaire.
Mori et al. 2006	**Design:** RCT **Condition:** Musculoskeletal pain associated with Persian Gulf War Veteran Illness (GWVI). **Setting:** Hospital outpatient **Exercise intervention:** Aerobic, stretching **Adherence:** 3, 6 and 12 months	None provided	Exercise frequency Exercise time (minutes) Exercise intensity	Self-report exercise log including objective measures	Adherence = 100% completion of prescribed exercises
Munneke et al. 2003	**Design:** RCT **Condition:** RA **Setting:** Hospital outpatient **Exercise intervention:** Aerobic and strengthening **Adherence:** 2 years	None provided	Session attendance	Class register	Sufficient adherence = 50-75% attendance High adherence = 75-100% attendance
Neuberger et al. 1993	**Design:** Pilot study **Condition:** Rheumatoid arthritis **Setting:** Hospital outpatient **Exercise intervention:** Range of movement exercises **Adherence:** 3-16 weeks after the self-instructional programme completion	None provided	Exercise frequency	Self-report exercise log	No provided
Newman-Beinart et al. 2016	**Design:** Questionnaire development **Condition**: Chronic low back pain **Setting:** Hospital outpatient **Exercise intervention**: Not stated **Adherence:** 3 and 7 weeks	No	Exercise frequency Exercise repetitions	EARS self-report questionnaire	No
Nordgren et al. 2014	**Design:** Observational cohort study **Condition:** RA **Setting:** Hospital outpatient	None provided	Exercise frequency Session attendance	Short form of the International Physical Activity	Adherence = 50% of circuit training sessions and 70%

	Exercise intervention: Aerobic and strengthening **Adherence:** 1 year			Questionnaire (IPAQ) Exercise Stage Assessment Instrument (ESAI) Text messages to collect data on number of days exercised each week Class register	total Health Enhancing Physical Activity (HEPA)
O'Brien et al. 2013	**Design:** Feasibility study using randomised controlled design **Condition:** Hip or knee OA **Setting:** Community **Exercise intervention:** Aerobic, strengthening and stretching **Adherence:** 12 weeks	None provided	Session attendance Exercise frequency Participant's exertion Participant's compliance with HCP instructions Participant's receptivity to programme change	Class register SIRAS Self-report exercise rating	Adherence = attending at least 1 class per week (3 advised i.e. 33%). Mean class attendance of 16/31 (intervention) and 17/31 (control) described as low. SIRAS of 4.5/5 (intervention) and 4.6/5 (control) described as high. Self-report exercise rating ranging from 3.5/5 to 3.9/5 described as high
Peterson et al. 2015	**Design:** RCT **Condition:** Chronic whiplash **Setting:** Primary Care **Exercise intervention:** Aerobic/Strengthening/Postural	No	Session attendance Behavioural components	Session attendance Self-report exercise log	Compliance = at least 50% attendance at sessions

	Adherence: 3 and 6 months				
Petrofsky & Laymon 2016	**Design:** RCT **Condition:** Chronic knee pain **Setting:** Hospital outpatient **Exercise intervention:** Strengthening/Stretching/Postural **Adherence:** 2 weeks	No	Exercise time	Self-report exercise log	No
Petty & Mastria 1983	**Design:** Case study **Condition**: Chronic back pain **Setting:** Hospital outpatient **Exercise intervention:** Strengthening and relaxation **Adherence:** Weekly for 23 weeks	None provided	Exercise frequency	Self-report exercise log	Adherence to 80% of prescribed exercises was described as 'moderate'
Pisters et al. 2010a	**Design:** Cluster randomised trial **Condition:** Hip or knee OA **Setting:** Primary care **Exercise intervention:** Aerobic, strengthening and stretching **Adherence:** Weeks 13 and 65	None prescribed	Sessions completed	Participants self-rated their adherence to recommendations for home exercises and activities on a 5-point scale where 1 = almost never; 5 = very often	Adherence = a self-report of 4 (often adherent) or 5 (very often adherent).
Pisters et al. 2010b	**Design:** Prospective observational study **Condition:** Hip or knee OA **Setting:** Primary care **Exercise intervention:** Aerobic, strengthening and stretching **Adherence:** 3, 15 and 60 months	"Adherence was defined as the extent to which a person's behaviour corresponds to agreed recommendations by the patient's physical therapist"[3]	Sessions completed	Participants self-rated their adherence to recommendations for home exercises and activities on a 5-point scale where 1 = almost never; 5 = very often	Adherence = a self-report of 4 (often adherent) or 5 (very often adherent).
Rejeski et al. 1997	**Design:** Single blind randomised controlled trial	None provided	Exercise time (minutes)	Self-report exercise log	None provided

	Condition: Knee OA **Setting:** Not stated **Exercise intervention:** Aerobic and strengthening **Adherence:** 3,9 and 16 months		Session attendance	Class register	
Resnick et al. 2008	**Design:** RCT **Condition:** Post hip fracture **Setting:** Hospital outpatient **Exercise intervention:** Aerobic, strengthening and stretching **Adherence:** 12 months	Adherence rates are defined as the total number of sessions completed/the total number of sessions included in the intervention.	Session attendance, the Exercise intensity Exercise time (minutes)	Data collected by HCPs at sessions	None provided
Robinson et al. 2004	**Design:** Telephone follow up study **Condition:** Chronic musculoskeletal pain **Setting:** Hospital outpatient **Exercise intervention:** Not stated **Adherence:** >6 months post intervention	"the extent to which a person's behaviour (in terms of medications, following diets, or executing lifestyle changes) coincides with medical or health advice"[1]	None provided	Participant Compliance Reporting Scale (PCRS) Health Professional Compliance Evaluation (HPCE) Both of the above used self-reported compliance ratings out of 100.	None provided
Rosal et al. 2011	**Design:** RCT protocol **Condition:** Total knee replacement **Setting:** Hospital pre-op then inpatient, then outpatient **Exercise intervention:** Not specified **Adherence:** 8 weeks, 6 and 12 months	None provided	Exercise intensity Session completion Exercise frequency	Objective physical function measures Self-report exercise log	None provided
Schneiders et al. 1998	**Design:** Randomised prospective survey **Condition:** Non-specific LBP **Setting:** Private physiotherapy **Exercise intervention:** Not specified	"Compliance to a therapeutic regimen is defined as the extent to	Exercise frequency	Self-report exercise log	None provided

	Adherence: 14 days	which a person's behaviour coincides with health advice"[27]			
Schoo et al. 2005a	**Design:** Randomised trial **Condition:** Hip or knee osteoarthritis **Setting:** Private physiotherapy **Exercise intervention:** Strengthening and stretching **Adherence:** 4 and 8 weeks	"Adherence can be defined as the level of compliance with a prescribed exercise program."[18]	Exercise replication Exercise frequency	Correctness of Exercise Performance Scale (COEP) Self-report exercise log	Median home exercise adherence rates of between 87% and 93% were described as 'high'.
Schoo et al. 2005b	**Design:** Cohort study **Condition:** Hip and knee OA **Setting:** Hospital outpatient and private physiotherapy **Exercise intervention:** Strengthening and stretching **Adherence:** 4 and 8 weeks	None provided	Exercise frequency Exercise replication Participant's exertion Participant's compliance with HCP instructions Participant's receptivity to programme change	Self-report exercise log COEP SIRAS	None provided
Seckin et al. 2000	**Design:** Cohort study **Condition:** Knee OA **Setting:** Not stated **Exercise Intervention:** Strengthening, stretching and functional. **Adherence:** 3 months	None provided	Exercise frequency	Interview	The observed compliance rate (85-90% across time points) was described as 'high'.
Taal et al. 1993	**Design:** Cohort study **Condition:** RA **Setting:** Hospital outpatient **Exercise intervention:** Not stated **Adherence:** 4 weeks	None provided	Problems adhering with recommendations	Interview using a "problem-index" which ranged from 0 (no problems) to 1 (problems with every recommendation).	None provided

Terpstra et al. 1992	**Design:** Retrospective study **Condition:** RA **Setting:** Hospital-out patient **Exercise intervention:** Not specified **Adherence:** Between 6-18 months	None provided	Exercise frequency	Questionnaire	Very compliant = exercising 1-2 times per day for at least 6 body parts (prescribed dose was for 7 body parts daily) i.e. 86%.
Thompson et al. 2016	**Design:** Systematic review **Condition**: Chronic pain **Setting:** Various **Exercise intervention**: n/a **Adherence:** n/a	"The extent to which a person's behaviour (in terms of medications, following diets, or executing lifestyle changes) coincides with medical or health advice"[3]	None provided in addition to those in included articles	None provided in addition to those in included articles	None provided in addition to those in included articles
Tilbrook et al. 2014	**Design:** Methodological study nested in RCT **Condition:** Chronic LBP **Setting:** Primary care **Exercise intervention:** Yoga **Adherence:** 3, 6 and 12 months	None provided	Session attendance Sessions completed	Class register Self-report exercise log	Adherence = attendance at 6 out of the 12 sessions, i.e. 50%.
Tuakli-Wosornu et al. 2016	**Design:** Secondary analysis of RCT **Condition**: Knee OA **Setting:** Hospital outpatient **Exercise intervention**: Aerobic/Strengthening/Stretching/Postural **Adherence:** Bi-weekly for 12 weeks	No	Session attendance Exercise frequency	Telephone interview	Non-adherence = less than 50% prescribed exercises.
Van Dillen et al. 2016	**Design:** RCT **Condition:** Chronic low back pain **Setting:** Community **Exercise intervention:** Other: Motor	No	Exercise frequency	Self-report exercise log	No

	control and movement training, performance training **Adherence:** Daily for 6/52, then at 6/12 and 12/12				
Van Gool et al. 2005	**Design:** RCT **Condition:** Knee OA **Setting:** Community **Exercise intervention:** Aerobic and strengthening **Adherence:** 6 and 18 months	None provided	Sessions attended Sessions completed	Class register Self-report exercise log	Participant's exercise adherence scores were split into 3 equally sized tertiles: low <40%, intermediate 41–70%, and high >71%.
Van Koppen et al. 2016	**Design:** Observational study **Condition**: Non-specific low back pain **Setting:** Private physiotherapy **Exercise intervention**: Aerobic **Adherence:** Daily for 1 week	"The extent to which a person's behaviour (in terms of medications, following diets, or executing lifestyle changes) coincides with medical or health advice"[3]	Exercise time Exercise intensity Barrier list	DynaPort MoveMonitor which measures intensity and duration of physical activity and if the device is being worn	100% adherence required to be classed as adherent
Waggoner & LeLieuvre 1981	**Design:** Multiple time series **Condition:** RA with hand involvement **Setting:** Hospital outpatient **Exercise intervention:** Strengthening **Adherence:** Weekly over 7 weeks.	"100% adherence to the exercise regimen. Any deviance from 100% was described as non-compliance."[28]	Exercise frequency	Objective measure Self-report exercise log	Adherence = completion of 100% of the prescribed exercise regimen.
Wig et al. 2004	**Design:** Cohort study **Condition:** Temporomanibular Disorder **Setting:** Hospital outpatient **Exercise intervention:** Stretching and relaxation **Adherence:** 3x daily for 2 weeks	"The extent to which a person's behaviour (in terms of taking medications, following diets, or	Exercise frequency	Self-report exercise log	Adherence = completion of 1 out of 3 exercises per day for 2 weeks, i.e. 33%.

		executing lifestyle changes) coincides with medical or health advice."[1]			
Zandwijk et al. 2015	**Design:** Observational study **Condition**: Non-specific low back pain **Setting:** Private physiotherapy **Exercise intervention**: Aerobic **Adherence:** Daily for 1 week	No	Exercise time Exercise intensity Barrier list	DynaPort MoveMonitor which measures intensity and duration of physical activity and if the device is being worn	100% adherence required to be classed as adherent

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Table 1. Details of the included studies

Authors	Year	Country	Setting	Study Design	MSK Pain Condition	Exercise Type	Adherence Measurement Time-Point
Alexandre et al.	2002	USA	Hospital outpatient	Prospective cohort study	LBP	Aerobic, strengthening, stretching and postural	2-6 weeks
Almekinders & Almekinders	1994	USA	Private physiotherapy	Retrospective study	Chronic overuse sports injury	Strengthening and stretching	27 months on average
Anderson	2011	Denmark	Community	Prospective study	Neck and shoulder pain	Strengthening	10 weeks
Basler et al.	2007	Germany	Hospital inpatient	Prospective randomised trial	Chronic LBP	Aerobic, strengthening, stretching	6-7 weeks and 6 months
Beinart et al.	2013	UK	Community	SR	Chronic LBP	Not extracted	Not extracted
Belza et al.	2002	USA	Community	RCT	OA	Aquatic	20 weeks
Bossen et al.	2013	Netherlands	Community	Mixed methods	Knee or hip OA	Aerobic	9 weeks
Bruno	1995	USA	Hospital inpatient and outpatient	Prospective cohort study	Back or neck pain	Aerobic, stretching, posture and self-care	12 weeks
Brus et al.	1997	Netherlands	Various	Literature review	RA	Not extracted	Not extracted
Brus et al.	1998	Netherlands	Hospital outpatient	RCT	RA	Aerobic	1 year
Byerly et al.	1994	USA	Private physiotherapy	Cohort study	Musculoskeletal injury	Not stated	Until discharged
Campbell et al.	2001	UK	Outpatient physiotherapy	Qualitative study	Patellofemoral OA	Strengthening	3 and 12 months
Carpenter & Davis	1976	USA	Hospital inpatient	Cohort study	RA	Not stated	4 months
Cheung et al.	2015	USA	Community	Cross sectional study	Knee OA	Yoga	6 months
Coppack et al.	2012	UK	Private physiotherapy	RCT	LBP	Aerobic, strengthening and stretching	3 weeks
Dalager et al.	2015	Denmark	Community	RCT	Neck and shoulder pain	Strengthening	20 weeks
Dobkin et al.	2006	Canada	Community	Prospective study	Fibromyalgia	Aerobic, strengthening and stretching	12 weeks
Dobkin et al.	2008	Canada	Hospital outpatient	Prospective study	Fibromyalgia	Aerobic, strengthening and stretching	3 months
Dobkin et al.	2009	Canada	Hospital outpatient	Prospective study	Fibromyalgia	Aerobic, strengthening and stretching	3 months

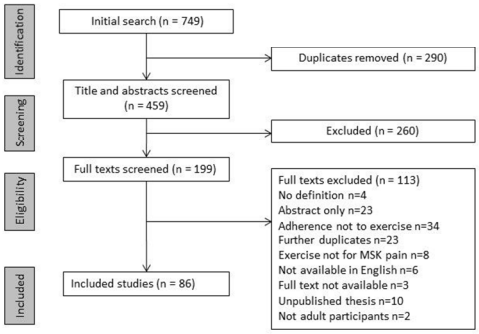
Ezzar et al.	2014	Canada	Various	SR	RA or OA	Not extracted	Not extracted
Ferguson & Bole	1979	USA	Hospital outpatients	Cohort study	RA	Not stated	Not stated
Friedrich et al.	1998	Austria	Hospital outpatients	RCT	LBP	Aerobic, strengthening and stretching	4 and 12 months
Frih et al.	2009	Tunisia	Hospital outpatients	RCT	LBP	Strengthening, stretching and self-positioning	4 weeks and 3 months
Frost et al.	2016	UK	Community	SR	MSK pain	Not extracted	Not extracted
Gisla et al.	2015	Germany	Hospital outpatient	Evidence based practice project	CLBP	Stretching	3, 6 and 12 months
Granlund et al.	1994	Sweden	Community	Cohort study	LBP	Aerobic, strengthening, stretching, postural and relaxation	5 and 10 months
Granlund et al.	1998	Sweden	Community	Cohort study	LBP	Strengthening & stretching	Weekly for 5 months
Hakkinen et al.	2004	Finland	Hospital outpatient	RCT	RA	Strengthening & stretching	2 and 5 years
Hall et al.	2015	Ireland	Various	SR	Chronic MSK conditions	Not extracted	Not extracted
Hammer et al.	2007	Sweden	Community	Descriptive and correlation	LBP	Repeated movements	2 months
Han et al.	2015	Singapore	Hospital outpatient	Retrospective database study	ACL reconstruction	Strengthening/Aerobic/Other: neuromuscular & sport specific training	1 year
Harkapaa et al.	1989	Finland	Hospital inpatient and hospital outpatient	Prospective RCT	LBP	Strengthening, stretching and postural	3 months
Harkapaa et al.	1990	Finland	Hospital inpatient and hospital outpatient	Prospective RCT	LBP	Strengthening, stretching and postural	2.5 years
Hartigan et al.	2000	USA	Hospital outpatient	Prospective observational study	Low back pain	Aerobic, strengthening, stretching	3 and 12 months
Hicks et al.	1985	USA	Various	Review	RA	Not extracted	Not extracted
Hicks et al.	2012	Italy	Community	Observational study	Back pain	Strengthening, postural, flexibility and aerobic	Continuously over 12 months
Holden et al.	2014	UK	Primary care	SR protocol	Musculoskeletal disorders	Any	N/A
Hugli et al.	2014	Switzerland	Community	RCT pilot	Non-specific low back pain	Motor control exercise	Average of 49 days
Huyser et al.	1997	USA	Hospital outpatient	RCT	Fibromyalgia	Aerobic, strengthening, stretching and postural	Weekly for 6 weeks
Jack et al.	2010	UK	Physiotherapy outpatient	SR	Musculoskeletal dysfunction	Not extracted	Not extracted
Jackson	1994	USA	Hospital inpatient	RCT	Back and/or neck pain	Not stated	3 weeks
Jansons et al.	2016	Australia	Various	SR	OA	Not extracted	Not extracted
Jordan et al.	2010	UK	Primary Care	SR	Chronic MSK pain	Not extracted	Not extracted
Kingston et al.	2014	Australia	Hospital outpatient	RCT	Traumatic hand injury	Not stated	6 weeks

Kolt & McEvoy	2003	Australia	Private physiotherapy clinics	Cohort study	Lumbar pain	Not stated	maximum 4 weeks
Lee et al.	2016	Hong Kong	Community	Mixed methods	Knee OA	Strengthening/Stretching/Other: range of movement	12 weeks
Linton & Jenson	1987	Sweden	Community	Cohort study	Neck and shoulder pain	Relaxation gymnastics	5 weeks
Linton et al.	1996	Sweden	Community	RCT	Back pain	Not stated	6 months
Loew et al.	2016	Canada	Community	Survey	Knee OA	Aerobic	3, 6 and 9 months
Lonsdale et al.	2012	Ireland	Outpatient physiotherapy	RCT outline	Low back pain	Not specified	4, 12 and 24 weeks
Lyncoln et al.	2002	Australia	Hospital inpatient	Cohort study	Distal fracture of radius	Strengthening, stretching and functional	6 weeks
Mailloux et al.	2006	USA	Hospital outpatient	Case series survey	Chronic back pain	Aerobics, strengthening and stretching	2 years
Mannion et al.	2009	Switzerland	Primary care/hospital outpatient	Prospective study	LBP	Spinal segmental stabilisation	9 weeks
Marks & Allegrante	2005	USA	N/A	Literature review	OA	Not extracted	Not extracted
Mayoux-Benhamou et al.	2008	France	Hospital outpatient	Prospective RCT	RA	Strengthening & stretching	6 and 12 months
Medina-Mirapeix et al.	2009	Spain	Primary care	Observational study	Chronic non-specific neck or low back pain	Strengthening and stretching	1 month
Mori et al.	2006	USA	Hospital outpatient	RCT	MSK pain	Aerobic and stretching	3, 6 and 12 months
Munnek et al.	2003	Netherlands	Hospital outpatient	RCT	RA	Aerobic and strengthening	2 years
Neuberger et al.	1993	USA	Hospital outpatient	Pilot study	RA	Stretching	3-16 weeks
Newman-Beinart et al.	2016	UK	Hospital outpatient	Questionnaire development	Chronic LBP	Not stated	3 and 7 weeks
Nordgren et al.	2014	Sweden	Hospital outpatient	Observational study	RA	Aerobic and strengthening	1 year
O'Brien et al.	2013	New Zealand	Community	Feasibility study	Hip or knee OA	Aerobic, strengthening and stretching	12 weeks
Peterson et al.	2015	Sweden	Primary care	RCT	Chronic whiplash	Aerobic/Strengthening/Postural	3 and 6 months
Petrofsky & Laymon	2016	USA	Hospital outpatient	RCT	Chronic knee pain	Strengthening/Stretching/Postural/Other: ROM	2 weeks
Petty & Mastria	1983	USA	Hospital outpatient	Case study	Chronic back pain	Strengthening and relaxation	Weekly for 23 weeks
Pisters et al.	2010a	Netherlands	Primary care	Cluster randomised trial	Hip or knee OA	Aerobic, strengthening and stretching	Weeks 13 and 65
Pisters et al.	2010b	Netherlands	Primary care	Prospective observational	Hip or knee OA	Aerobic, strengthening and stretching	3, 15 and 60 months

				study			
Rejeski et al.	1997	Canada	Not stated	RCT	Knee OA	Aerobic and strengthening	3, 9 and 16 months
Resnick et al.	2008	USA	Hospital outpatient	RCT	Post hip fracture	Aerobic, strengthening and stretching	12 months
Robinson et al.	2004	USA	Hospital outpatient	Telephone follow-up study	Chronic MSK pain	Not stated	Minimum 6 months
Rosal et al.	2011	USA	Hospital pre-op then inpatient, then outpatient	RCT protocol	Total knee replacement	Not specified	8 weeks, 6 and 12 months
Schneiders et al.	1998	Australia	Private physiotherapy	Randomised prospective survey	Non-specific LBP	Not specified	14 days
Schoo et al.	2005a	Australia	Private physiotherapy	Randomised trial	Hip or knee OA	Strengthening & stretching	4 and 8 weeks
Schoo et al.	2005b	Australia	Hospital outpatient and private physiotherapy	Cohort study	Hip and knee OA	Strengthening & stretching	4 and 8 weeks
Seckin et al.	2000	Turkey	Not stated	Cohort study	Knee OA	Strengthening, stretching and functional.	3 months
Taal et al.	1993	Netherlands	Hospital outpatient	Cohort study	RA	Not stated	4 weeks
Terpstra et al.	1992	Netherlands	Hospital outpatient	Retrospective study	RA	Not stated	6-18 months
Thompson et al.	2016	Australia	Various	SR	Chronic pain	Not extracted	Not extracted
Tilbrook et al.	2014	UK	Primary care	Methodological study	Chronic LBP	Yoga	3, 6 and 12 months
Tuakli-Wosornu et al.	2016	USA	Hospital outpatient	Secondary analysis of RCT	Knee OA	Aerobic/Strengthening/Stretching/Postural	Bi-weekly for 12 weeks
Van Dillen et al.	2016	USA	Community	RCT	Chronic LBP	Motor control and movement training, performance training	Daily for 6/52, then at 6/12 and 12/12
Van Gool et al.	2005	USA	Community	RCT	Knee OA	Aerobic and strengthening	6 and 18 months
Van Koppen et al.	2016	Netherlands	Private physiotherapy	Observational study	Non-specific LBP	Aerobic	1 week
Waggoner & LeLieuvre	1981	USA	Hospital outpatient	Multiple time series	RA with hand involvement	Strengthening	7 weeks.
Wig et al.	2004	USA	Hospital outpatient	Cohort study	TMJ disorder	Stretching & relaxation	3x daily for 2 weeks
Zandwijk et al.	2015	Netherlands	Private physiotherapy	Observational study	Non-specific LBP	Aerobic	1 week

Abbreviations: CLBP – chronic low back pain, ACL – anterior cruciate ligament, TMJ – temporo-mandibular joint, SR – systematic review
Not extracted – this data was not extracted as it was from studies included within SRs and therefore not eligible or already included separately.

Figure 1. PRSIMA flow diagram of study selection



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